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Technical Information
TST310

Resistance thermometer

Screw-in or insertion version
With connecting cable and anti-kink spring

Field of application

The resistance thermometer is suitable for temperature measurement in machinery, laboratory equipment and plants with gaseous or liquid media such as air, water, oil, etc.

Your benefits

- High degree of flexibility thanks to user-specific insertion lengths and variable process connections
- Fast response time
- Simple or duplex Pt100 sensor with accuracy class A, B, or AA according to IEC 60751
- Types of protection for use in hazardous locations:
  - Intrinsically safe (Ex ia)
  - Non-sparking (Ex nA)

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Table of contents

Function and system design

Measuring principle

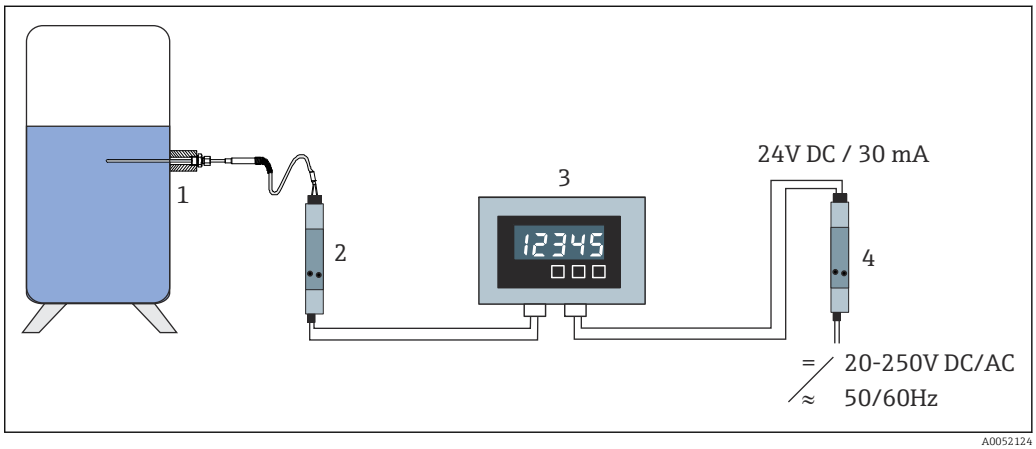
These resistance thermometers use a Pt100 temperature sensor according to IEC 60751. The temperature sensor used is a temperature-sensitive platinum resistor having a resistance of 100 Ω at 0 °C (32 °F) and a temperature coefficient a = 0.003851 $°C^{-1}$.

There are generally two different kinds of platinum resistance thermometers:

- **Wire-wound (WW):** In these thermometers, a double coil of fine, high-purity platinum wire is located in a ceramic support. This support is then sealed top and bottom with a ceramic protective layer. Such resistance thermometers not only facilitate very reproducible measurements but also offer good long-term stability of the resistance/temperature characteristic within temperature ranges up to 600 °C (1 112 °F). This type of sensor is relatively large in size and is comparatively sensitive to vibrations.
- **Thin-film platinum resistance thermometers (TF):** A very thin, ultrapure platinum layer (approx. 1 µm thick) is vaporized in a vacuum on a ceramic substrate and then structured photolithographically. The platinum conductor paths formed in this way create the measuring resistance. Additional covering and passivation layers are applied and reliably protect the thin platinum layer from contamination and oxidation, even at high temperatures.

The primary advantages of thin-film temperature sensors compared to wire-wound versions are their smaller dimensions and better vibration resistance. In the case of thin-film sensors, their resistance/temperature characteristic can often deviate slightly from the standard characteristic of IEC 60751 at higher temperatures because of their operating principle. As a result, the tight limit values of tolerance class A as per IEC 60751 can only be adhered to using thin-film sensors at temperatures up to approx. 300 °C (572 °F). For this reason, thin-film sensors are generally only used for temperature measurements in ranges below 400 °C (932 °F).

Measuring system



1 Application example

1 Installed thermocouple thermometer TST310
2 Temperature transmitter iTEMP TMT71 The temperature transmitter is a 2-wire device with one measuring input and one analog output. The device not only transfers converted signals from resistance thermometers and thermocouples, it also transmits resistance and voltage signals using a 4 to 20 mA current signal.
3 RIA16 field indicator - The indicator records the analog measuring signal from the temperature transmitter and shows it on the display. The LC display shows the current measured value in digital form and as a bar graph indicating a limit value violation. The indicator is looped into the 4 to 20 mA circuit and gets the required energy from there. More information on this can be found in the Technical Information (see "Documentation").
4 Single-channel active barrier - The active barrier is used for the transmission and galvanic isolation of 0/4 to 20 mA/HART signals. The device has an active/passive current input to which a 2-wire or 4-wire transmitter can be directly connected. The output of the device can be operated actively or passively. The current signal is then available to the PLC/controller or to other instrumentation at plug-in screw terminals or optional push-in terminals.

Input

Measurement range

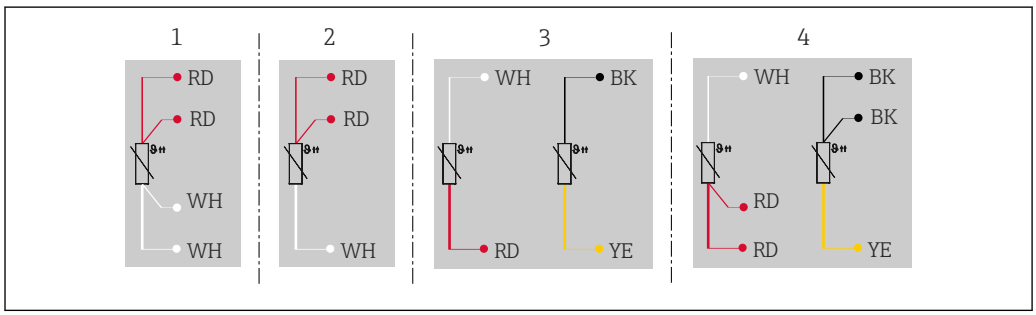
- −200 to +600 °C (−328 to +1 112 °F), bendable version, mineral-insulated sheathed cable
- −50 to +250 °C (−58 to +482 °F) non-bendable version, insulated sensor wires in stainless steel pipe
- Cable resistance: Sensor cable resistance up to max. 50 Ω per cable

Power supply

Wiring diagram

The thermometer is wired with the flying leads of the connection cable. The thermometer can be connected to a separate temperature transmitter, for example.

Core cross-section: ≤ 0.382 mm² (AWG 22) with end sleeves, length = 5 mm (0.2 in).



2 *Wiring diagram*

1 1 x Pt100, 4-wire
2 1 x Pt100, 3-wire
3 2 x Pt100, 2-wire
4 2 x Pt100, 3-wire

For a 2-wire connection, please take into account the influence of the cable resistance on the overall accuracy. To ensure reasonable accuracy of a 2-wire connection, a cable length < 400 cm (157 in) is recommended. Alternatively, a 3-wire or 4-wire connection should be used.

For the highest accuracy, a 4-wire connection is recommended or use of a transmitter.

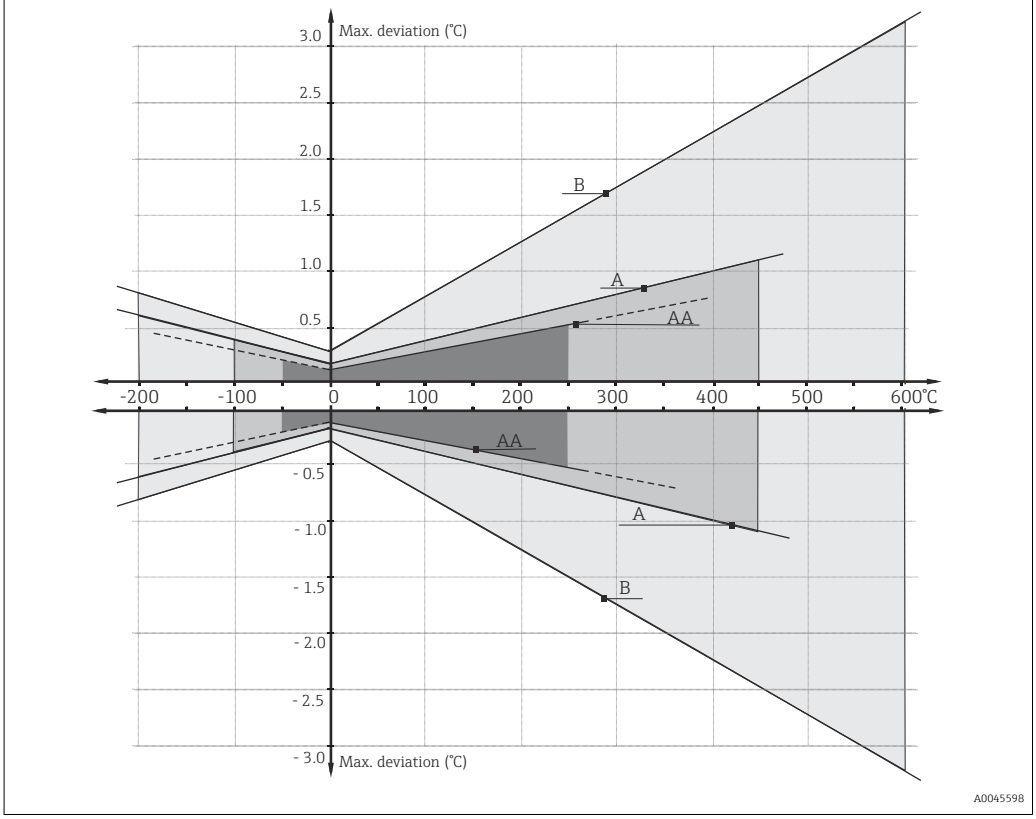
Performance characteristics

Maximum measured error

RTD resistance thermometer as per IEC 60751

Class	Max. tolerances (°C)
Cl. AA, formerly 1/3 Cl. B	± (0.1 + 0.0017 · |t| [1)])
Cl. A	± (0.15 + 0.002 · |t|)
Cl. B	± (0.3 + 0.005 · |t|)
Temperature range for compliance with the tolerance classes Thin-film version (TF): Cl. A −30 to +200 °C	

Characteristics



1) |t| = absolute temperature value in °C

To obtain the maximum tolerances in °F, multiply the results in °C by a factor of 1.8.

Response time

Tests were performed in water at 0.4 m/s (according to IEC 60584) and with a 10 K temperature step change. Measuring probe Pt100, TF/WW:

Cable sensor diameter	Response time	
Mineral-insulated cable		
6 mm (0.24 in)	t_{50}	3.5 s
	t_{90}	8 s
3 mm (0.12 in)	t_{50}	2 s
	t_{90}	5 s
Insulated sensor wires		
6 mm (0.24 in)	t_{50}	9 s
	t_{90}	28 s
3 mm (0.12 in)	t_{50}	6 s
	t_{90}	18 s

Response time for RTD cable sensor without transmitter

Insulation resistance

Insulation resistance (at 100 V DC) ≥100 MΩ at ambient temperature.

Self-heating

RTD elements are passive resistors that are measured using an external current. This measurement current causes a self-heating effect in the RTD element itself which in turn creates an additional

measurement error. In addition to the measurement current, the size of the measurement error is also affected by the temperature conductivity and flow velocity of the process. This self-heating error is negligible when an Endress+Hauser iTEMP temperature transmitter (very low measured current) is used.

Calibration

Endress+Hauser provides comparison temperature calibration from −80 to +600 °C (−110 to 1 112 °F) based on the International Temperature Scale (ITS90). Calibrations are traceable to national and international standards. The calibration certificate is referenced to the serial number of the thermometer.

Cable sensor: Ø6 mm (0.24 in) and Ø3 mm (0.12 in)	Minimum insertion length of cable sensor
Temperature range	
−80 to −40 °C (−110 to −40 °F)	No minimum immersion length required
−40 to 0 °C (−40 to 32 °F)	
0 to 250 °C (32 to 480 °F)	
250 to 550 °C (480 to 1020 °F)	300 mm (11.81 in)

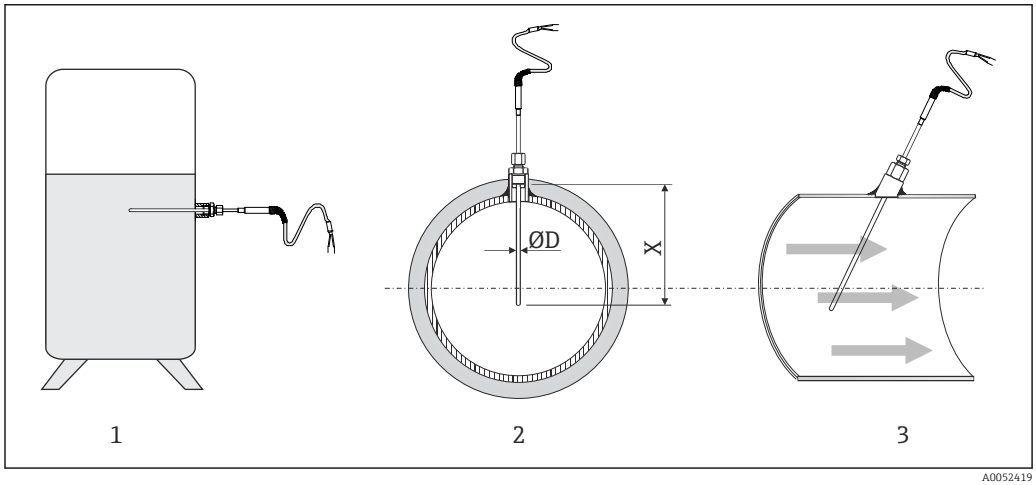
Installation

Installation conditions

Orientation

No restrictions

Installation instructions



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3 Installation examples

1 Installation in a tank
2 In the case of cables with a small cross-section, the sensor tip must reach as far as the pipe axis or a little farther (=X)
3 Angled orientation

The immersion length of the thermometer can influence the accuracy. If the immersion length is too short, errors in the measurement can be caused by heat conduction via the process connection and the vessel wall. For installation in a pipe therefore, the immersion length should ideally be half of the pipe diameter (see Figure "Installation examples", item 2).

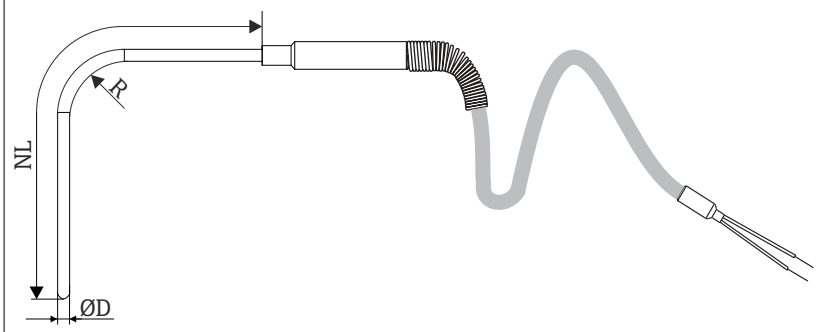
- Installation options: Pipes, tanks or other plant components
- The insertion length for the bendable version should correspond to at least around 10 times the cable sensor diameter (Ø D), while the insertion length for the non-bendable version with insulated sensor wires should correspond to around 30 times the cable sensor diameter (Ø D). Example: Diameter 3 mm (0.12 in) x 30 = 90 mm (3.54 in). A standard insertion length of > 60 mm (2.36 in) is recommended for the bendable version and > 180 mm (7.1 in) for the non-bendable version.
- ATEX certification: Observe the installation instructions in the Ex documentation!

For pipes with small diameters, sometimes only small thermometer insertion lengths are possible. Improvements can be achieved by installing the thermometer at an angle (see Figure "Installation examples", item 3). To determine the insertion length required for measurement purposes, the parameters of the thermometer and of the process to be measured must always be taken into consideration (e.g. flow velocity, process pressure). Installation of the thermometer in a thermowell is not recommended.

Bendable cable sensor

Cable sensors with an MgO sheathed cable are bendable, taking into account the minimum dimensions specified in the table. Bending of cable sensors with insulated sensor wires is not permitted.

Bending radius R



- R >15 mm (0.6 in) with ØD = 3 mm (0.12 in), NL ≥ 25 mm (1 in)
- R >30 mm (1.2 in) with ØD = 6 mm (0.24 in), NL ≥ 65 mm (2.56 in)

Environment

Ambient temperature range

The permitted ambient temperature depends on the material used for the electrical connecting cable and the cable sheath insulation:

Material Connecting cable/tube insulation	Max. temperature in °C (°F)
PVC/PVC	80 °C (176 °F)
PTFE/silicone	180 °C (356 °F)
PTFE/PTFE	200 °C (392 °F)

Shock and vibration resistance

Max. 3 G/10 to 500 Hz as per IEC 60751 (RTD thermometer)

Degree of protection

IP65

Process

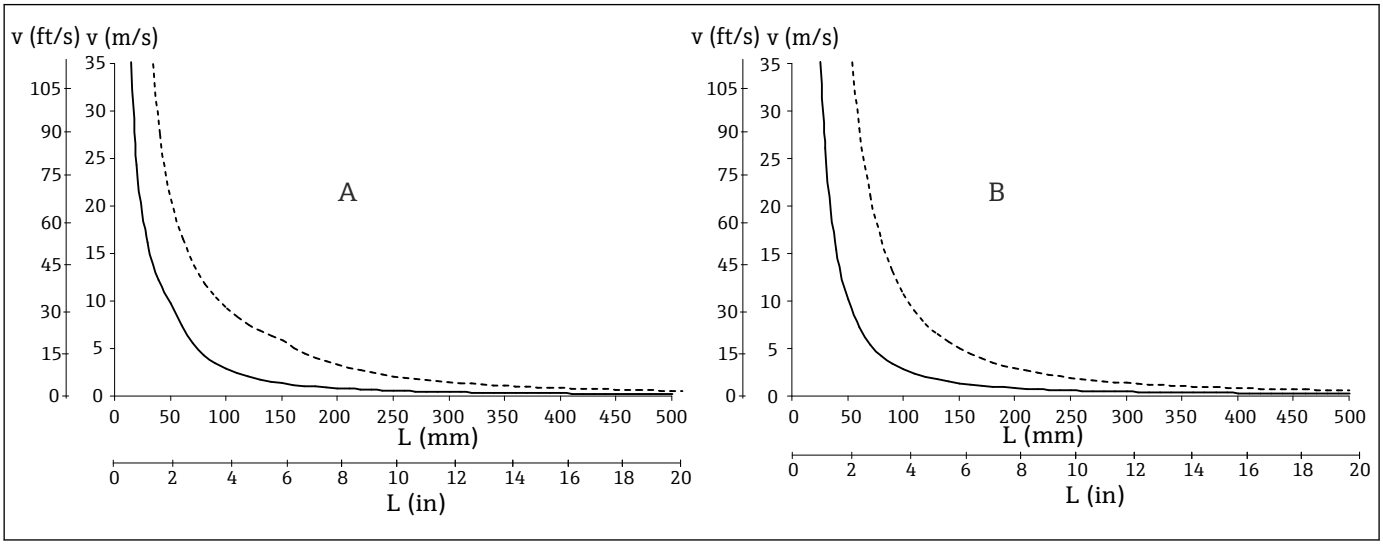
Process pressure range

Max. process pressure (static) ≤ 75 bar (1 088 psi).

For information on the maximum permitted process pressures for the individual process connections, see the "Process connection" section → 🖹 9.

Permitted flow velocity depending on the immersion length

The highest flow velocity tolerated by the thermometer diminishes with increasing sensor immersion length exposed to the stream of the fluid. It is also dependent on the diameter of the thermometer tip, the type of medium being measured, the process temperature and the process pressure. The following figures exemplify the maximum permitted flow velocities in water and superheated steam at a process pressure of 1 MPa (10 bar).

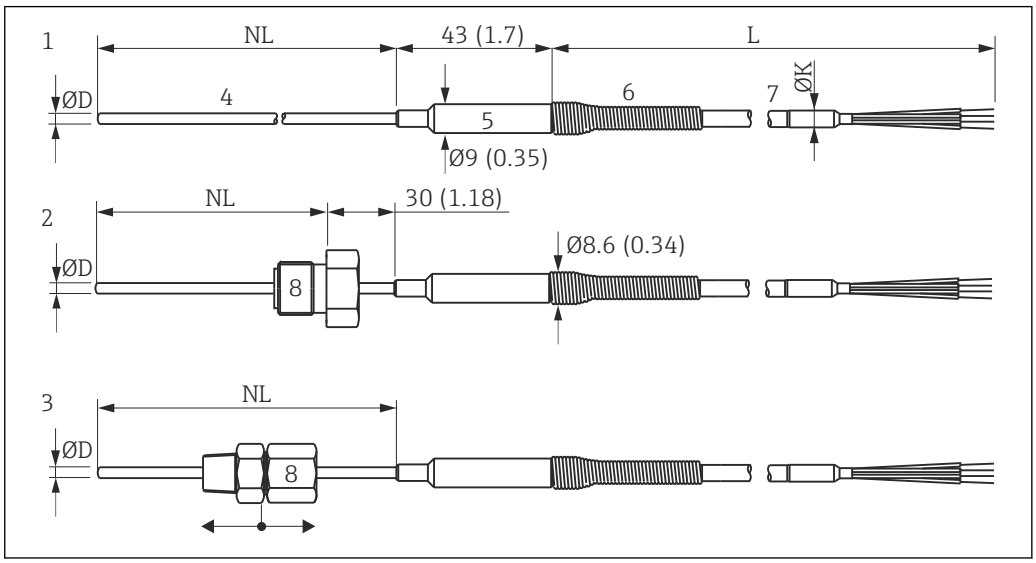


4 *Permitted flow velocity: Ø 3 mm (0.12 in) (solid line), Ø 6 mm (0.24 in) (dashed line)*

A Medium water at T = 50 °C (122 °F)
B Medium superheated steam at T = 400 °C (752 °F)
L Immersion length
v Flow velocity

Mechanical construction

Design



5 *Design of TST310, dimensions in mm (in)*

1 Without process connection
2 With brazed process connection
3 With adjustable compression fitting
4 Cable sensor with ØD = 3 mm (0.12 in) or 6 mm (0.24 in)
5 Transition sleeve
6 Anti-kink spring, 50 mm (1.97 in)
7 Connecting cable with variable cable diameter ØK; see 'Connecting cable' table
8 Process connection versions
L Length of connecting cable
NL Insertion length

The resistance thermometers in the TST310 series are designed as cable sensors. The actual sensor element of the resistance thermometer sits in the sensor tip and is mechanically protected. In principle, there are bendable and non-bendable versions of the cable sensor (→ 4). The cable sensors are generally made of a stainless steel pipe in which the connection wires of the sensor element are connected to provide electrical insulation. Only the bendable version uses mineral-insulated sheathed cables instead. The corresponding connecting cable is fastened to the sensor by means of a transition sleeve.

The thermometer can be installed using either an adjustable compression fitting or a process connection brazed onto the thermometer. Versions for insertion without special process connection are also available.

For detailed information on the process connection, see → 9.

Connecting cable

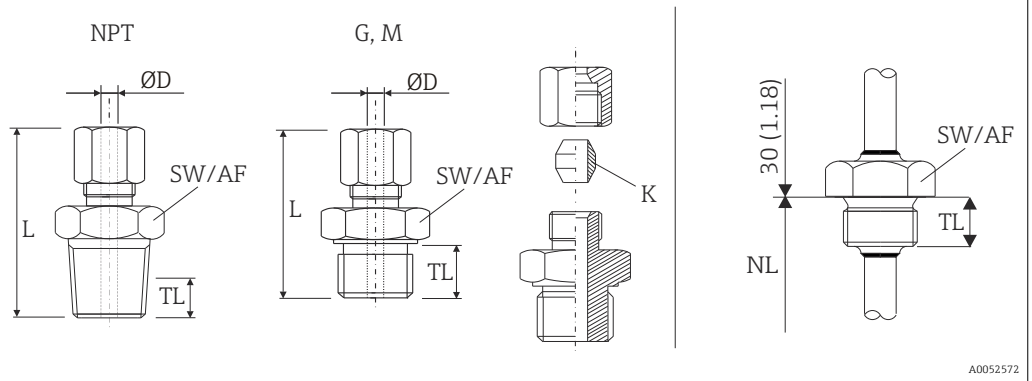
Cable insulation; sheathing; connecting wires	Option	Cable diameter ØK in mm (in)
PVC; PVC; 4-wire	A	4.8 (0.19)
PTFE; silicone; 4-wire	B	4.6 (0.18)
PTFE; PTFE; 4-wire	C	4.5 (0.178)
PTFE; silicone; 2x3-wire	D	5.2 (0.2)
PTFE; silicone; 4-wire	E	4.0 (0.16)

Process connection

The process connection refers to the connection between the thermometer and the process. This connection is established by the connection thread, brazed with a fixed position or adjustable compression fitting. When a compression fitting is used, the thermometer is pushed through a gland and fastened by means of a ferrule.

- **Brazed process connection thread**
  Maximum pressure: 75 bar (1088 psi) at 20 °C (68 °F).
- **SS316 compression ferrule**
  Can only be used once; the position of the compression fitting can no longer be changed after it is first mounted. Fully adjustable insertion length on initial installation. Maximum pressure: 40 bar (580 psi) at 20 °C (68 °F).
- **PTFE compression ferrule**
  Can be reused; once loosened, the compression fitting can be moved up and down the thermowell. Fully adjustable insertion length. Maximum process temperature: 180 °C (356 °F), maximum pressure: 5 bar (73 psi) at 20 °C (68 °F).

Process connection	
Adjustable compression fitting with connection thread	Brazed process connection



Dimensions in mm (in), NL = insertion length

Version	Thread and width across flats		L in mm (in)	TL in mm (in)	Clamping ring material	Max. process temperature	Max. process pressure
TA50 (compression fitting)	G⅛"	SW/AF 14	35 (1.38)	10 (0.4)	SS 316 [1]	800 °C (1472 °F)	40 bar (580 psi) at 20 °C (68 °F)
					PTFE [2]	200 °C (392 °F)	10 bar (145 psi) at 20 °C (68 °F)
	G¼"	SW/AF 19	40 (1.57)	10 (0.4)	SS 316 [1]	800 °C (1472 °F)	40 bar (580 psi) at 20 °C (68 °F)
					PTFE [2]	200 °C (392 °F)	10 bar (145 psi) at 20 °C (68 °F)
	G½"	SW/AF 27	47 (1.85)	15 (0.6)	SS 316 [1]	800 °C (1472 °F)	40 bar (580 psi) at 20 °C (68 °F)
					PTFE [2]	200 °C (392 °F)	10 bar (145 psi) at 20 °C (68 °F)
	NPT⅛"	SW/AF 12	35 (1.38)	4 (0.16)	SS 316 [1]	800 °C (1472 °F)	40 bar (580 psi) at 20 °C (68 °F)
	NPT¼"	SW/AF 14	40 (1.57)	6 (0.24)			
	NPT½"	SW/AF 22	50 (1.97)	8 (0.32)			
	M10x1	SW/AF 14	35 (1.38)	10 (0.4)	PTFE [2]	200 °C (392 °F)	10 bar (145 psi) at 20 °C (68 °F)
	M8x1	SW/AF 12					
Process connection, brazed	G¼"	SW/AF 17	-	12 (0.47)	-	800 °C (1472 °F)	75 bar (1087 psi) at 20 °C (68 °F)
	G½"	SW/AF 27		15 (0.6)			

Version	Thread and width across flats		L in mm (in)	TL in mm (in)	Clamping ring material	Max. process temperature	Max. process pressure
	M10x1	SW/AF 14		10 (0.4)			
	M8x1	SW/AF 12					

1) SS316 compression ferrule: Can only be used once; once loosened, the compression fitting can no longer be positioned on the thermowell. Fully adjustable immersion length on initial installation
2) PTFE compression ferrule: Can be reused; the compression fitting can be moved up and down the thermowell after loosening. Fully adjustable immersion length

Materials

Cable sensors and process connection

The temperatures for continuous operation specified in the following table are only intended as reference values for use of the various materials in air and without any significant compressive load. The maximum operating temperatures are reduced considerably in some cases where abnormal process conditions such as high mechanical load occur or in aggressive media. The measuring range of the temperature sensor must also be taken into account (→ 🖹 4).

Material name	Short form	Recommended max. temperature for continuous use in air	Properties
AISI 316L/ 1.4404	X2CrNiMo17-12-2	650 °C (1200 °F)	▪ Austenitic, stainless steel ▪ High corrosion resistance in general ▪ Particularly high corrosion resistance in chlorine-based and acidic, non-oxidizing atmospheres through the addition of molybdenum (e.g. phosphoric and sulfuric acids, acetic and tartaric acids with a low concentration) ▪ Increased resistance to intergranular corrosion and pitting
AISI 316Ti/ 1.4571	X6CrNiMoTi17-12- 2	700 °C (1472 °F)	▪ Properties comparable with AISI316L ▪ Addition of titanium provides increased resistance to intercrystalline corrosion even after welding ▪ Broad range of uses in the chemical, petrochemical and oil industries as well as in coal chemistry ▪ Can only be polished to a limited extent, titanium streaks can form

Connecting cable insulation

Material name	Properties
PVC (polyvinyl chloride)	▪ Very resistant to acid ▪ High degree of hardness, resistance to inorganic chemicals, particularly acids and alkalis ▪ Low impact strength and low temperature stability
Silicone	▪ Permanently elastic at high and low temperatures ▪ Aging and weather-resistant ▪ Ozone and UV-resistant ▪ Oil, solvent and fuel-resistant (fluorine silicones), water-repellent ▪ Flue-gas resistant
PTFE	▪ Resistance to almost all chemicals ▪ Good mechanical loading capacity over a wide temperature range ▪ Operating temperature up to 200 °C (392 °F)

Weight

≥ 100 g (3.53 oz), depending on the version, e.g. 150 g (5.3 oz) for version NL = 100 mm (3.93 in) and brazed process connection G½".

Spare parts

Spare parts	Order no.
Ø6.1 mm (0.24 in); G¼", G⅜", G½", G¾, ¼" NPT, ½" NPT, ¾" NPT; ferrule material PTFE (10 units)	60011600
Ø3 mm (0.12 in); G⅛", G¼"; ferrule material PTFE (10 units)	60011598
Ø6.1 mm (0.24 in); G¼", G⅜", G½", G¾, ¼" NPT, ½" NPT, ¾" NPT; ferrule material SS 316 (10 units)	60011599
Ø3 mm (0.12 in); G⅛", G¼"; ferrule material SS 316 (10 units)	60011575

Certificates and approvals

Current certificates and approvals for the product are available at www.endress.com on the relevant product page:

1. Select the product using the filters and search field.
2. Open the product page.
3. Select **Downloads**.

Ordering information

Detailed ordering information is available from your nearest sales organization www.addresses.endress.com or in the Product Configurator at www.endress.com:

1. Select the product using the filters and search field.
2. Open the product page.
3. Select **Configuration**.

Product Configurator - the tool for individual product configuration

- Up-to-the-minute configuration data
- Depending on the device: Direct input of measuring point-specific information such as measuring range or operating language
- Automatic verification of exclusion criteria
- Automatic creation of the order code and its breakdown in PDF or Excel output format
- Ability to order directly in the Endress+Hauser Online Shop

Supplementary documentation

The following types of documentation are available on the product pages and in the Download Area of the Endress+Hauser website (www.endress.com/downloads) (depending on the selected device version):

Document	Purpose and content of the document
Technical Information (TI)	**Planning aid for your device** The document contains all the technical data on the device and provides an overview of the accessories and other products that can be ordered for the device.
Brief Operating Instructions (KA)	**Guide that takes you quickly to the 1st measured value** The Brief Operating Instructions contain all the essential information from incoming acceptance to initial commissioning.
Operating Instructions (BA)	**Your reference document** The Operating Instructions contain all the information that is required in various phases of the life cycle of the device: from product identification, incoming acceptance and storage, to mounting, connection, operation and commissioning through to troubleshooting, maintenance and disposal.
Description of Device Parameters (GP)	**Reference for your parameters** The document provides a detailed explanation of each individual parameter. The description is aimed at those who work with the device over the entire life cycle and perform specific configurations.
Safety Instructions (XA)	Depending on the approval, Safety Instructions (XA) are supplied with the device. The Safety Instructions are an integral part of the Operating Instructions. Information on the Safety Instructions (XA) that are relevant for the device is provided on the nameplate.
Supplementary device-dependent documentation (SD/FY)	Always comply strictly with the instructions in the relevant supplementary documentation. The supplementary documentation is an integral part of the device documentation.

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